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Techniques for the Reduction of Cyclic Errors in Laser Metrology Gauges for the Space Interferometry Mission

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The Space Interferometry Mission ("SIM", see <http://sim.jpl.nasa.gov>), scheduled for launch in 2008, is an optical stellar interferometer with a 10 meter baseline capable of micro-arcsecond accuracy astrometry. A mission-enabling technology development program is underway at JPL, including the design and test of heterodyne interferometer metrology gauges to monitor the geometry of the spacecraft structure and optical components. The gauges are required to have a resolution of 10 picometers over several meters of motion.

A persistent difficulty in attaining picometer-class performance with laser interferometric metrology gauges is the problem of "cyclic error" caused by the leakage of a small fraction of light to the photodetectors via routes that do not reflect the distance being measured. For example, gauges based on polarizing optics exhibit nonlinearity with a one-wavelength periodicity, typically several nm in amplitude.

We survey a variety of approaches to reducing this cyclic error and their application in reaching SIM's 10 pm goal. These include optimizing field amplitudes and polarization alignment, developing interferometric gauges that do not depend on polarization, and attenuating residual periodic error by ramping the frequency and modulating the phase of the input light. We describe an experimental apparatus capable of resolving 20 picometer periodic error, and present data showing attenuation of this error to below 100 picometers.